REPORT ON THE IMPLEMENTATION OF SB 18-086

OCTOBER 1, 2021

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Overview

C.R.S. 24-33.5-1905 (4) directs the Department of Higher Education (DHE, the Department) to prepare a report detailing progress made towards critical state cyber-security goals at institutions of higher education that received an appropriation through SB 18-086. Specifically, the report must include, at a minimum:

1. The number of faculty or adjunct faculty hired at each institution of higher education as a result of the funding;
2. The number of student internships created with the funding at each institution of higher education;
3. The number of degrees or certificates that have been awarded at each institution of higher education in connection with the funding;
4. The number of scholarships awarded at each institution in connection with the funding;
5. The number of presentations and seminars given on cybersecurity by each institution of higher education; and
6. The amount of all other money that has been raised to match the state investment, which may include tuition, fees, federal funds, and industry donations.

Six governing boards were awarded funding in the 2020-21 fiscal year. The following report summarizes their spending.

Key Findings

Fiscal Year 2020-21 was the third year in which funding was awarded to support cybersecurity and distributed ledger technology activities at institutions. Despite the impact of the COVID-19 pandemic on campus operations, institutions remained committed to offering cybersecurity activities and programming to both students and their communities.

Table 1 shows, by governing board, SB 18-086 appropriation, actual expenditures, required scholarship award total, and actual scholarships awarded.

	SB 18-086 Appropriation	Total Amount Expended	SB 18-086 Scholarship Requirement	Total Amount Spent on Scholarships
Colorado Mesa University	$182,352	$239,797	$18,235	$40,460
Metropolitan State University of Denver	$182,352	$286,702	$18,235	$45,750
Western State Colorado University	$121,568	$248,990	$12,157	$27,300
Colorado State University System	$729,412	$670,979	$109,412	$518,267
University of Colorado System	$1,701,964	$1,701,964	$255,295	$392,494
Colorado Community College System	$182,352	$182,352	$18,235	$27,500

Fiscal Year (FY) 2020-21 was the third year in which institutions received this funding. In addition to several programs requiring a longer period of implementation, the COVID-19 pandemic also caused interruptions on campuses across the state. As institutions continue to receive funding to support cybersecurity programs, the amount of programming they are able to offer will likely increase.

Table 2 summarizes activities funded by SB 18-086 funding.

	Faculty and Adjuncts Hired	Internships Created	Degrees and Certificates Awarded	Scholarships Awarded	Presentations and Seminars Given	Amount of Other Funding Raised
Colorado Mesa University	1.5	13	9	23	25	$72,002
Metropolitan State University of Denver	8	24	29	35	0	$106,000
Western Colorado University	0.97	1	2	4	0	$127,422
Colorado State University System	19	164	116	185	48	$3,611,369
University of Colorado System	37.1	46	500	197	127	$9,356,403
Colorado Community College System	2	25	59	11	47	$50,000

Full Institutional Responses

Institutions used the funds received to support a wide range of public facing activities, such as hosting summer camps, presenting at conferences, and offering trainings for community members. Institutions also raised significant additional funds to support their work in the cybersecurity realm. For additional details on institutional activities and fund raised, each institution's full response has been included in the subsequent pages. In some cases, responses have been edited for formatting and grammar but are otherwise unchanged.

COLORADO MESA UNIVERSITY

SB 18-086 Appropriation Expenditure Report		
Governing Board Name	Colorado Mesa University	
Total SB 18-086 Appropriation		$ 182,352
Actual Amount Spent on Scholarships		$ 40,460
Total number of scholarships awarded		23
Required Allotted Amount Earmarked for Scholarships		$ 18,235
At or above allotted amount of scholarship earmark		Yes
Number of faculty/adjucts hired as a result of funding		1.5
Number of student interships created		13
Number of degrees/certificates awareded in connection with SB 086 funding		9
Number of presentations/seminars given on cybersecurity		25
Amount of all other money raised to match state investment		72,002
Total Amount Expended		$ 239,797

Please discuss any additional ways in which SB 086 money was spent, which may not be captured in lines 6-9 and fundraising efforts as reported in FY21 and any other information you would like to be included in the report.

$25,838 was used to hire student workers in the Cybersecurity center. These students were all in the cybersecurity program.

In addition, research in the Cybersecurity Center has resulted in 4 publications in scholarly journals in the last year.

Students graduating from the cybersecurity program are now employed in corporations including: Los Alamos National Lab, Epic, Lockheed Martin, Comcast, Aspen Technology Groups, and Deloitte

Two graduates of the program are now in graduate cybersecurity programs.

METROPOLITAN STATE UNIVERSITY

SB 18-086 Appropriation Expenditure Report		
Governing Board Name	Metropolitan State University of Denver	
Total SB 18-086 Appropriation		$ 182,352
Actual Amount Spent on Scholarships		$ 45,750
Total number of scholarships awarded		35
Required Allotted Amount Earmarked for Scholarships		$ 18,235
At or above allotted amount of scholarship earmark		Yes
Number of faculty/adjucts hired as a result of funding		8
Number of student interships created		24
Number of degrees/certificates awareded in connection with SB 086 funding		29
Number of presentations/seminars given on cybersecurity		0
Amount of all other money raised to match state investment		106,000.00
Total Amount Expended	Metropolitan State University of Denver	$ 286,702

Please discuss any additional ways in which SB 086 money was spent, which may not be captured in lines 6-9 and fundraising efforts as reported in FY21 and any other information you would like to be included in the report.

The department continued funding a Cybersecurity Program Manager and a full-time Cybersecurity specialist faculty in Computer Information Systems with SB 18-086 monies and this FY21, we hired a Cyber Range Director with SB 086 money. Additionally, in FY21 $100,000 was allocated and spent from SB 086 to build a state of the art cyber range, that was completed in the Summer of 2021.

The Bachelor of Science Degree in Cyber Security

The Bachelor of Science Degree in Cyber Security successfully launched in Fall 2018 with 47 majors. Currently, (Fall of 2020) the B.S. in Cybersecurity has 214 majors. A Master's Degree in Cybersecurity started in the Fall of 2019 with 15 students and current class has 40 students.

Faculty

The department continued funding a Cybersecurity Program Manager and a full-time Cybersecurity specialist faculty in Computer Information Systems with SB 18-086 monies and this FY21, we hired a Cyber Range Director

with funding from Senate Bill 18-086 and private donation monies. Additionally, MSU-Denver has continued to hire 7 part-time faculty to teach 18 sections of Cybersecurity undergraduate courses each Fall, Spring and Summer.

Scholarship
MSU-Denver created a scholarship in Fall of 2018 and have allocated 10% of the annual SB 18-086 awards to be distributed for scholarships. In FY 21, $45,750 was awarded to 35 students to make up for lack of applicants in past fiscal years.

Other areas and institutional matches
In FY21 $100,000 was allocated from SB 18-086 to build a state-of-the-art cyber range, matched with $450,000 plus from MSU-Denver and $81,000 from the private sector and the range was completed in August of 2021.

Graduates or Certificates
There were 8 STEMPath students that earned graduate certificates in Cybersecurity. The 8 students are current teachers in Denver Public Schools and Aurora Public Schools, who will teach Cybersecurity to K-12 students in their respective school districts in their individuals classrooms or Cybersecurity/Computer labs. Additionally, 5 students received their Master's degree in Cybersecurity and finally, 16 received their B.S. in Cybersecurity for the FY21.

Amount of matching monies, including tuition, fees, federal funds, and industry donations
In FY21, the program received $81,000 to support the Cyber Range Director position and another $25,000 was donated support Cybersecurity student scholarships.

WESTERN COLORADO UNIVERSITY

SB 18-086 Appropriation Expenditure Report		
Governing Board Name	Western Colorado University	
Total SB 18-086 Appropriation		$ 121,568
Actual Amount Spent on Scholarships		$ 27,300
Total number of scholarships awarded		4
Required Allotted Amount Earmarked for Scholarships		$ 12,157
At or above allotted amount of scholarship earmark		Yes
Number of faculty/adjucts hired as a result of funding		0.97 FTE ($73,519)
Number of student interships created		1
Number of degrees/certificates awareded in connection with SB 086 funding		2
Number of presentations/seminars given on cybersecurity		0 due to COVID
Amount of all other money raised to match state investment		$127,422
Total Amount Expended		$ 248,990

Please discuss any additional ways in which SB 086 money was spent, which may not be captured in lines 6-9 and fundraising efforts as reported in FY21 and any other information you would like to be included in the report.

Computer camp ($20,000): 15 flash drives for campers, copy costs for camp, faculty salaries for camp, student helpers for camp, students lunch each day at camp, actively participated in Mountain West Cyber Consortium, 2 TAs for CS330- a core class for information security, information security guest speaker in the spring.

CSU SYSTEM

SB 18-086 Appropriation Expenditure Report		
Governing Board Name	Colorado State University System	
Total SB 18-086 Appropriation		$ 729,412
Actual Amount Spent on Scholarships		$ 518,267
Total number of scholarships awarded		185
Required Allotted Amount Earmarked for Scholarships		$ 109,412
At or above allotted amount of scholarship earmark		Yes
Number of faculty/adjucts hired as a result of funding		19
Number of student interships created		164
Number of degrees/certificates awareded in connection with SB 086 funding		116
Number of presentations/seminars given on cybersecurity		48
Amount of all other money raised to match state investment		$ 3,611,369
Total Amount Expended		$ 670,979

Please discuss any additional ways in which SB 086 money was spent, which may not be captured in lines 6-9 and fundraising efforts as reported in FY21 and any other information you would like to be included in the report.

695 students were enrolled in IT Sec courses in FY 21

University of Colorado, Colorado Springs (UCCS)

Cybersecurity Initiative (CSI)

FY21 Annual Report

September 2021

Approved:

Dr. Kelli Klebe
Provost
University of Colorado, Colorado Springs
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Executive Summary

On May 30th, 2018, former Governor Hickenlooper signed Senate Bill (SB) 18-086 granting UCCS $2.8 million annually for workforce development, research and development, and support to law enforcement enhancing cybersecurity for the State and the Nation. In May 2021, the bill was extended for another three year term. This document provides a consolidated report of FY 2021 CSI expenditures as required by SB18-086.

Altogether, UCCS in partnership with the National Cybersecurity Center (NCC) spent all of the FY 2021 State appropriation, $1,701,964 (the 39.5% cut approved last year) shown in Figure 1. Additionally, over $ 9,356,403in grants and additional funds were awarded to, and obtained by, UCCS, NCC and Space ISAC. These numbers are also reported in Figure 1.

Figure 1: SB18-086 Reporting Criteria

SB 18-086 Appropriation Expenditure Report		
Governing Board Name	University of Colorado System	
Total SB 18-086 Appropriation	$	1,701,964
Actual Amount Spent on Scholarships	$	392,494
Total number of scholarships awarded	197	
Required Allotted Amount Earmarked for Scholarships	$	255,295
At or above allotted amount of scholarship earmark	Yes	
Number of faculty/adjucts hired as a result of funding		37.1%
Number of student interships created	46	
Number of degrees/certificates awareded in connection with SB 086 funding	500	
Number of presentations/seminars given on cybersecurity	127	
Amount of all other money raised to match state investment	9,356,403	
Total Amount Expended	$	1,701,964
Please discuss any additional ways in which SB 086 money was spent, which may not be captured in lines 6-9 and fundraising efforts as reported in FY21 and any other information you would like to be included in the report.		
$80,000 Blockchain research (see below)	**$67,369 Cybersecurity training for local law enforcement and public officials (see below)**	

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In addition to SB18-086 reporting criteria, the impact of the state's investment in the Colorado cybersecurity ecosystem including academic and community programs, industry outreach and partnership and filling workforce needs cannot be understated. These efforts are critical to Colorado's supporting the myriad elements of US Space Command remaining in Colorado and to continue being a national leader in public and private sector activities related to cybersecurity. The following narrative provides more detail on the comprehensive impact these funds have had on UCCS efforts to engage, support and grow cybersecurity in Colorado and beyond.

Together, UCCS and NCC are continuing along the path of exponentially expanding the cybersecurity ecosystem with initiatives, programs, research and partnerships that are paying large dividends by enhancing cybersecurity for Colorado and the Nation. Both UCCS and NCC are grateful to the Colorado Legislature and Governor for giving us this opportunity.

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University of Colorado Colorado Springs

UCCS has leveraged SB-086/CSI $1,701,964 (39.5% reduced budget) in 2021 from the JBC to achieve the following under the broad legislation requirements:

Scholarship Amount – $392,494 (exceeded 15% legislative requirement of the reduced budget last year, additional scholarships awarded through additional funding sources)

- Engineering students were awarded cybersecurity scholarships totaling $225,294
- Business students were awarded cybersecurity scholarships $30,000
- UCCS was awarded funding from NSA for DoD Scholarship for Service (SFS) program- 6 cybersecurity students (1 PhD, 1 MS and 4 Undergraduate) – $271,396
- Space ISAC and UCCS provided joint funding for cybersecurity students - $3,000
- The NCC, based on additional funds leveraged as a result of state money, offered non-academic scholarship funds in FY 2020
    - Cybersecurity Classes/Certifications – $106,800
    - Student Cyber Camps – $30,400

Total Students Scholarships Awarded – 197

- 18 graduate and 41 undergraduate Engineering cybersecurity students
- 61 Business cybersecurity students
- Space ISAC, in partnership with UCCS, provided paid Graduate Fellowship and Undergraduate Scholar opportunities for 2 students in 2020-2021 to expand their awareness and involvement in the growing cybersecurity and space connections.
- The NCC, based on additional funds leveraged as a result of state money, offered 75 additional scholarships to adult and high school students participating in cyber security camps

Faculty Hires – 8

- **College of Engineering and Applied Science (EAS)**
    - With additional funding, UCCS hired the endowed Gallogly Chair Professor in Cybersecurity, Dr. Shouhuai Xu, with 20 years of research and educational leadership in cybersecurity. He has extensive research collaborations with DOD scientists and an outstanding record of federal research funding. He is national and world leader in cybersecurity metrics research and pioneered the Cybersecurity Dynamics framework for quantifying cybersecurity from a holistic perspective. Within six months of his employment, Dr. Xu has brought to UCCS two NSF research grants worth $960K as PI and another Air Force research grant worth of $15K as co-PI.
    - EAS is still employs 2 assistant faculty and 4 instructors with this funding - cybersecurity areas of focus for these faculty include **cybersecurity operations and security in intelligent transportation and privacy and anonymous networks.**
        - Planning on hiring a 3rd faculty in 2021-2022

    - One of these employed faculty, Dr Gedare Bloom, received a prestigious NSF Career award for $599K to support his cutting edge research in real-time systems security from 7/2022-7/2027.
- **Cybersecurity Program Office** -still employing the Director of Cybersecurity Programs with this funding
    - Additional funding allowed this office to grow from 1 to 7 employees, 2 positions from the CU President funds, 2 from a NSA CAE grant, and 2 student employees.
- **College of Business** is still employing 1 tenure track faculty with this funding
    - Two additional tenure track faculty are planned for College of Business 2021-2022
- **The NCC,** based on additional funds leveraged as a result of state money, were able to hire three new employees working cybersecurity projects

Student Internships Created – 46

- **UCCS cybersecurity students** obtained 19 cybersecurity internships in 2020-2021
- **UCCS EAS Blockchain research project** supports 10 part-time interns and directly executes the legislative SB18-086 requirement to conduct research and development on encryption and data integrity techniques
- **The NCC** hosted 10 high school cybersecurity students during the summer and five college students to help with student cyber camps and one summer intern supported the Elections Program
- NCC, in partnership with Daniels Funds, provided paid Undergraduate and Graduate Internships for 2 students in Spring 2020.
- **The Space ISAC** hosted three cybersecurity college interns for Summer 2020, two undergraduate students and one graduate fellow that conducted strategic planning and evaluation of the cybersecurity threat intelligence platform

Degrees and Certificates Awarded - 500

In addition to the degrees and certificates awarded below, UCCS Engineering and Applied Science School and Cybersecurity Program Office are working to redesignate their Cybersecurity degree programs at the ME, PhD and BS levels under the National Security Agency (NSA) Center of Academic Excellence (CAE) in cybersecurity program.

- **UCCS EAS/COB degrees – 123 graduated**
    - Bachelor Degree in Innovation – graduated 2020-2021 43; Enrolled 204
    - Bachelors of Science – graduated 2020-2021 80; Enrolled 365
    - BS in Business Emphasis Area in Cybersecurity Management – Graduated 2020-2021 2; Enrolled 15
    - **Bachelor of Arts in Computer Science (BACS) Cybersecurity – 44 Enrolled**
        - this was the first year this program was offered and was a VERY popular option with Community College, transfer and new incoming students.
    - Masters Degree in Computer Science – Graduated 2020-02021 4; Enrolled 40
    - Masters Degree in Cybersecurity-Graduated 2020-2021 7; Enrolled 16
    - MBA Emphasis in Cybersecurity Management – New fall 2021 Enrolled 11
    - Doctor of Philosophy Degree – graduated 2020/2021 1; Enrolled 39
    - Doctor of Business Administration in Cybersecurity Management –New Fall 2021; Enrolled 15
    - **UCCS certificates – 3**

  - Network System Security -2
  - Undergraduate Applied Cybersecurity Certificate – 1
  - CoB Graduate Certificate in Cybersecurity Management – 30 enrolled
  - CoB Undergraduate Certificate in Cybersecurity Management – 114 enrolled

- **The School of Letters, Arts and Sciences developed a multi-disciplinary bachelor's degree in cybersecurity which will begin in Fall Semester 2021**
- **The School of Public Affairs has developed a cybersecurity policy, legal and forensics concentration for students that will begin Fall Semester 2021**
- Three NCC cybersecurity non-credit programs were offered during this past FY. Many of the students and adults who completed the cybersecurity courses earned nationally recognized certifications in areas such as IT Fundamentals and Security+
  - Cyber camps – 112 participants
  - NCC Student Alliance (NCCSA) in Cybersecurity (CTSO) – 440 participants (308 students, 70% achieved certification)
  - Cybersecurity training – Adults – 75 participants (69 adults, 90% achieved certification)
- The cybersecurity building and Space ISAC construction, funded by over $5M raised last year, is underway providing over 25,00 ft^2 of cybersecurity office, lab, classroom and collaboration space. Anticipated completion is March 2022
- Space ISAC raised an additional $500K this year from the Economic Development Council to provide the infrastructure for their facility in the UCCS Cybersecurity Building.

Seminars, Publications and Presentations on Cybersecurity – 127

- **School of Engineering and Applied Sciences – 12 Publications**
  - **Gedare Bloom,** Joel Sherrill, Tingting Hu, Ivan Cibrario Bertolotti, Real-Time Systems Development with RTEMS and Multicore Processors, CRC Press, DOI: 10.1201/9781351255790, 2020.
  - James Marshall, Robert Gifford, **Gedare Bloom**, Gabriel Parmer, Rahul Simha, Precise Cache Profiling for Studying Radiation Effects, in ACM Transactions on Embedded Computing Systems, vol. 20, iss. 3, pp. 25:1-25:25,DOI: 10.1145/3442339, 2021.
  - Uchenna Ezeobi, Habeeb Olufowobi, Clinton Young, Joseph Zambreno, **Gedare Bloom**, Reverse Engineering Controller Area Network Messages using Unsupervised Machine Learning, in IEEE Consumer Electronics Magazine, pp. 1-1,DOI: 10.1109/MCE.2020.3023538, 2020.
  - Habeeb Olufowobi, Clinton Young, Joseph Zambreno, **Gedare Bloom,** SAIDuCANT: Specification-Based Automotive Intrusion Detection Using Controller Area Network (CAN) Timing, in IEEE Transactions on Vehicular Technology, vol. 69, iss. 2, pp. 1484-1494,DOI: 10.1109/TVT.2019.2961344, 2020.
  - **Gedare Bloom**, WeepingCAN: A Stealthy CAN Bus-off Attack, in Workshop on Automotive and Autonomous Vehicle Security, Internet Society,DOI: https://dx.doi.org/10.14722/autosec.2021.23002, 2021.
  - Prajjwal Dangal**, Gedare Bloom**, Towards Industrial Security Through Real-time Analytics, in 2020 IEEE 23rd International Symposium on Real-Time Distributed Computing (ISORC), pp. 156-157,DOI: 10.1109/ISORC49007.2020.00036, 2020.

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- **Gedare Bloom**, Joel Sherrill, Harmonizing ARINC 653 and Realtime POSIX for Conformance to the FACE Technical Standard, in 2020 IEEE 23rd International Symposium on Real-Time Distributed Computing (ISORC), pp. 98-105,DOI: 10.1109/ISORC49007.2020.00023, 2020.
- **Terrance Boult**, **Yanyan Zhuang**, "PORT: Pooled Ordered Rectangular Testing for Improved Public Health Screening", in Proc. 9th IEEE International Conference on Healthcare Informatics (ICHI'21), Victoria, British Columbia, Canada, August 2021 (h-index: 21).
- Mark Vaszary, Andreas Slovacek, **Yanyan Zhuang**, **Sang-Yoon Chang**, "Securing Tire Pressure Mon- itoring System for Vehicular Privacy", in Proc. 18th IEEE Consumer Communications and Network- ing Conference (CCNC'21), Las Vegas, Nevada, USA, January 2021 (h-index: 27).
- Mong Sim, **Yanyan Zhuang**, "A Dual Lockstep Processor System-on-a-Chip for Fast Error Recovery in Safety-Critical Applications", in Proc. 46th IEEE Annual Conference of the Industrial Electronics Society (IECON'20), Singapore, October, 2020 (h-index: 26).
- Mong Sim, **Yanyan Zhuang**, "Design of Two Interleaved Error Detection and Corrections using Hsiao Code and CRC", in Proc. 46th IEEE Annual Conference of the Industrial Electronics Society (IECON'20), Singapore, October, 2020 (h-index: 26).
- Mong Sim, **Yanyan Zhuang**, "A SpaceWire PHY with Double Data Rate and Fallback Redundancy", in Proc. 33rd IEEE International System-on-Chip Conference (SOCC'20), Las Vegas, Nevada, USA, September, 2020
- D. Li, Q. Li, Y. Ye, and **S. Xu**. Arms Race in Adversarial Malware Detection: A Survey. Accepted to ACM Computing Survey, 2021.
- Deqiang Li, Tian Qiu, Shuo Chen, Qianmu Li, and **Shouhuai Xu**. Can We Leverage Predictive Uncertainty to Detect Dataset Shift and Adversarial Examples in Android Malware Detection? Accept to the 2021 Annual Computer Security Applications Conference (ACSAC 2021).
- Huashan Chen, Hasan Cam, and **Shouhuai Xu**. Quantifying Cybersecurity Effectiveness of Dynamic Network Diversity. Accepted to IEEE Transactions on Dependable and Secure Computing (TDSC), 2021.
- Wenjun Fan, **Sang-Yoon Chang**, **Xiaobo Zhou**, and **Shouhuai Xu**. ConMan: A Connection Manipulation-based Attack Against Bitcoin Networking. Accepted to the 9th IEEE Conference on Communications and Network Security (CNS 2021).
- **S. Xu.** SARR: A Cybersecurity Metrics and Quantification Framework (Keynote). The 3rd International Conference on Science of Cyber Security (SciSec'2021).
- J. Charlton, P. Du, and **S. Xu**. A New Method for Inferring Ground-Truth Labels and Malware Detector Effectiveness Metrics. The 3rd International Conference on Science of Cyber Security (SciSec'2021).
- **S. Xu**, M. Yung, and J. Wang. Seeking Foundations for the Science of Cyber Security. Information Systems Frontiers 23 (2), 263-267
- L. Tao, L. Chen, L. Xu, **S. Xu**, Z. Gao, W. Shi and D. Huang. Hardness and Algorithms for Electoral Manipulation under Media Influence. The 15th Frontiers of Algorithmics Workshop, 2021.
- V. Trieu-Do, R. Garcia-Lebron, M. Xu, **S. Xu**, and Y. Feng. Characterizing and Leveraging Granger Causality in Cybersecurity: Framework and Case Study. EAI Endorsed Transactions on Security and Safety 7 (25), e4

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- Z. Li, D. Zou, **S. Xu**, Z. Chen, Y. Zhu, and H. Jin. VulDeeLocator: A Deep Learning-based Fine-grained Vulnerability Detector. In IEEE Transactions on Dependable and Secure Computing (TDSC), 2021.
- Q. Chen, P. Romanowich, J. Castillo, K. Roy, G. Chavez, and **S. Xu**. ExHPD: Exploiting Human, Physical and Driving Behaviors to Detect Vehicle Cyber Attacks. IEEE Internet of Things Journal, 2021
- Y. Han, W. Lu, and **S. Xu**. Preventive and Reactive Cyber Defense Dynamics with Ergodic Time-dependent Parameters Is Globally Attractive. IEEE Transactions on Network Science and Engineering (TNSE), 2021.
- Z. Fang, M. Xu, **S. Xu**, and T. Hu. A Framework for Predicting Data Breach Risk: Leveraging Dependence to Cope with Sparsity. IEEE Transactions on Information Forensics & Security (T-IFS). 16, 2186-2201
- D. Li, Q. Li, Y. Ye, and **S. Xu**. Enhancing Deep Neural Networks Against Adversarial Malware Examples. IEEE Transactions on Network Science and Engineering (TNSE), accepted for publication, 2021.
- Z. Li, D. Zou, **S. Xu**, H. Jin, Y. Zhu, Z. Chen, S. Wang, and J. Wang. SySeVR: A Framework for Using Deep Learning to Detect Software Vulnerabilities. IEEE Transactions on Dependable and Secure Computing (TDSC), accepted for publication, 2021

- **Keynote, and panel and other presentations in year 2021:**
  - **Shouhuai Xu**. SARR: A Cybersecurity Metrics and Quantification Framework. Keynote Address at the 3rd International Conference on Science of Cyber Security (SciSec'2021).
  - **Shouhuai Xu**. Moderator of Panel discussion entitled "Where Are Cybersecurity Boundaries?" at the 3rd International Conference on Science of Cyber Security (SciSec'2021).
  - **Shouhuai Xu**. Cybersecurity Metrics and Quantification: Problems, Some Results, and Research Directions. The Defense and Aerospace Test and Analysis Workshop (DataWorks'2021), April 12, 2021.
- **School of Business – 1 Publication**
  - Mohammed, Z., Tejay, G. (2021) Examining the Privacy Paradox through Individuals' Neural Disposition in E-commerce: An Exploratory Neuroimaging Study. Computers & Security, 104(May).
- **Scholarship for Service students – 9 publications**
  - Manohar Raavi, Simeon Wuthier, Pranav Chandramouli, Yaroslav Balytskyi, **Xiaobo Zhou**, and **Sang-Yoon Chang**, Security Comparisons and Performance Analyses of Post-Quantum Signature Algorithms, International Conference on Applied Cryptography and Network Security (ACNS), 2021, Virtual (Acceptance rate: 16.9% - 13 out of 77 in the first round)
  - Jinoh Kim, Makiya Nakashima, Wenjun Fan, Simeon Wuthier, **Xiaobo Zhou**, Ikkyun Kim, and **Sang-Yoon Chang**, Anomaly Detection based on Traffic Monitoring for Secure Blockchain Networking, IEEE International Conference on Blockchain and Cryptocurrency (ICBC), 2021, Virtual (Acceptance rate: 17.8% - 34 out of 191)
  - Kay Yoon and **Sang-Yoon Chang**, Teaching Team Collaboration in Cybersecurity: A Case Study from A Transactive Memory Systems Perspective, IEEE Global Engineering Education Conference (EDUCON), 2021, Vienna, Austria

- Hsiang-Jen Hong, Wenjun Fan, Simeon Wuthier, Jinoh Kim, **Xiaobo Zhou**, **C. Edward Chow**, and **Sang-Yoon Chang**, Robust P2P Connectivity Estimation for Permissionless Bitcoin Network, IEEE/ACM International Symposium on Quality of Service (IWQoS), 2021, Virtual
- Manohar Raavi, Pranav Chnadrmouli, Simeon Wuthier, **Xiaobo Zhou**, and **Sang-Yoon Chang**, Performance Characterization of Post-Quantum Digital Certificates, IEEE International Conference on Computer Communications and Networks (ICCCN), 2021, Virtual
- Mark Vaszary, Andreas Slovacek, **Yanyan Zhuang**, and **Sang-Yoon Chang**, Securing Tire Pressure Monitoring System for Vehicular Privacy, IEEE Consumer Communications & Networking Conference (CCNC), 2021, Virtual
- Wenjun Fan, Hsiang-Jen Hong, Simeon Wuthier, **Xiaobo Zhou**, Yan Bai, and **Sang-Yoon Chang**, Security Analyses of Misbehavior Tracking in Bitcoin Network, IEEE International Conference on Blockchain and Cryptocurrency (ICBC), 2021, Virtual
- Simeon Wuthier and **Sang-Yoon Chang**, Demo: Proof-of-Work Network Simulator for Blockchain and Cryptocurrency Research, IEEE International Conference on Distributed Computing Systems (ICDCS), 2021, Virtual
- **Sang-Yoon Chang** and Simeon Wuthier, Dynamic Power Control for Rational Cryptocurrency Mining, Proceedings of Workshop on Cryptocurrencies and Blockchains for Distributed Systems (CryBlock), in conjunction with ACM MobiCom, 2020, Virtual

- **Cybersecurity Program Office - 25**
  - Presentations were given to ISSA, AFCEA, SBDC, 10 corporate partners, Space ISAC membership, American Competitiveness Exchange, incoming interim CU president, Senator Hickenlooper, Cyber First Fridays, NSA Centers of Academic Excellence, and many other local, national and international fora
- **National Cybersecurity Center – 40**
  - based on a combination of state and additional funds, participated in cybersecurity presentations (18) and seminars (22)
- **Space ISAC- 25**
  - Based on a combination of state and additional funds, attended and presented at national and international conferences including Advanced Threat Technical Exchange, Space Symposium, Cycon21, DEFCON, and Small Sat.

<u>Matching/additional grants</u> – just shy of $10M in NEW additional funding ($9,356,403)

- **UCCS School of Business - $6M**
  - Ongoing Grants
    - CAE Faculty Development -
    - US Department of Labor Grant - $6 million – Colorado Cybersecurity Apprenticeship Program (CCAP)
      - US DOL Standards Registered in Colorado
      - Programs include Cybersecurity Analyst (Spring 2021), Cybersecurity Penetration and Vulnerability Tester (Spring 2021) and IT Auditor (Fall 2021)
- **Cybersecurity Program Office - $800,000**
  - **NSA** $300,000 - Intro and Advanced GenCyber Camp for Teachers Summer 2022 – 2 year period

  - **CU** The CU President provided UCCS an additional $500,000 for cybersecurity programs in 2020-2021
    - 9 Faculty Seed grants totaling $65,000 were awarded to faculty in Engineering, Business, Education, Letters Arts and Sciences and Public Affairs to explore bringing cybersecurity into their programs and classes
    - 6 undergraduate students were provided summer research funding of $21,000 for working Cybersecurity research projects
    - The Cybersecurity Program Office received 2 FTE, a budget/HR/deputy position and a cybersecurity grant development and submission support position, increasing the office manning by 200% to support cross-disciplinary program development and activities
    - A sponsored programs compliance position (0.5 FTE) was created to systematize cybersecurity compliance and increase effectiveness of cybersecurity in grant submissions and execution
  - Ongoing Grants - $444,907
    - **NSA** $95,000 – Five GenCyber Middle School Summer weeklong cybersecurity camps - deferred from 2019-2020 because of Covid
    - **NSA** - $349,907 - CAE Northwest Hub grant – year 1 of 2

- **UCCS Engineering/Cybersecurity Grants –** $1,906,592 total
  - **NSF** $599,000 Career grant for Dr Gedare Bloom – 5 years
  - **NSF** $499,094 Assuring Cyber Security and Privacy for Human Resilience Research: Requirements, Framework, Architecture, Mechanisms and Prototype – 3 year
  - **NSF** $250,472 Game Theoretic Methods for Socially Networked Multi-Agent Systems – 3 year
  - **NSF** $438,823 A Framework for Enhancing the Resilience of Cyber Attack Classification and Clustering Mechanisms - 1 year
  - **Whatcom Community College** $119,194 Junior Reserve Officer Training Corps (JROTC) Cyber Academy Pilot Program - 1 year
  - Ongoing Grants - $2,822,521 total
    - **NSF** $97,000 Enforcing Security and Privacy Policies to Protect Research
    - **NSF** $36,620 BREAKTHROUGH in CYBERSECURITY
    - **NSA** $135,100 2019 DOD CYBER SCHOLARSHIP
    - **NSF** $692,500 REAL-TIME OPERATING SYSTEM
    - **NSF** $1,132,100 COLORADO-WASHINGTON SECURITY
    - **NSF** $20,620 Investigate and enhance cybersecurity of automotive systems
    - **NSF** $708,581 Cybersecurity hardening for scientific industrial control systems
- **NCC** leveraged state funds to obtain **$4,176,914** from multiple funding sources in FY 2020
- **SPACE ISAC – 1,803,000**
  - (EDA grant) leveraged state funds to obtain $803,000 from multiple funding sources in FY 2020 with membership dues valued at $1 million dollars.
- **BlockChain Development Community:** Volunteer Members and Companies provided 85.1% of 13,808 hours contributed to the effort from 2017-2020. In comparison to the $140,000 invested by the State this provides an equivalent in-kind community sponsored effort of $939,597.
- **BlockFrame Incorporated:** provided in-kind sponsorship providing media outreach services, refreshments and prizes, venue cost, and professional services for weekly meetings. These in-kind

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services and sponsorship over a three (3) year period provided matching support of approximately $30,000

- **Bees Computing & Ajames Technologies:** provided in-kind sponsorship including management platforms, volunteer and community coordination support platforms and services, IT Managed Services, and web repositories. These in-kind services and sponsorship over a four (4) year period provided matching support of approximately $52,000.

In addition to the University specific requirements, UCCS has undertaken significant work on legislation specific technical requirements:

- **UCCS School of Public Affairs - Public Safety Initiative (PSI) –** In support of SB 18-086 Section 4 24-33.5-1904 paragraph 2f, "Support state and federal law enforcement agencies with their responsibilities for investigating and collecting information related to cyber-based criminal and national security threats" has continued to facilitate professional development education and training for 16 area law enforcement agencies across Colorado.
    - Twenty-six Digital Forensic Investigators received cybercrime training, and two agencies received hardware and software to enhance their cybercrime investigative abilities.
    - One of the agencies that received support is the Colorado Springs Police Department (CSPD) Technical Investigations Section. This office investigates financial crimes, criminal transactions, and Internet Crimes Against Children (ICAC). The CSPD Digital Forensics Unit examines data from computers, cell phones, video surveillance systems, and many other digital storage devices.
    - PSI Support to Law Enforcement (LE) delivered $72,091 in cybercrime training and equipment to 16 area LE agencies sponsoring nine cybercrime investigation courses for 26 law enforcement Investigators
    - PSI delivers cybersecurity capability and expertise in an increasingly critical area of law enforcement
    - PSI offers insight and advice necessary to adapt and contend with a rapidly evolving cybersecurity threat
- **UCCS funded "Blockchain Research Program in Support of Colorado Senate Bill SB18-086,"** in support of the SB18-086 section two requirements. The largest efforts were in applied research evaluation and testing which led to several key developments:
    - The testing of performance and base operations of Project Philos™ distributed ledgers
    - the publication of the operations of the Synchronous Trust Consensus Model for peer review
    - the establishment of the International Alliance of Trust Chains (IATC) organization
    - the establishment of a for-profit organization to support the sales of tokens necessary to operate the Philos™ distributed ledger
        - *Distributed Ledger Project Philos™ has incorporated the needs for several other Colorado Legislation with the ability to support multiple state programs. Technology application implement provide for the a modular framework to include requirement from Colorado legislation including: SB13-246 Criminal Discovery Task Force, SB14-190 Statewide Discovery Sharing System, HB16-1377 Digital Task Force, HB16-1453 CO Cyber Security Initiative, HB18-1128 Personal Identifying Information, HB19-1247 Study Agricultural Applications for Blockchain, SB19-184 Colorado Water Institute blockchain, HB18-1220 Currency Exemption Money Transmitters Act*
    - the expansion of the BlockChain Development Community (BCDC) to multiple university chapters and engagement with a future alliance to expand worldwide dispersal

        - *Communities for Blockchain Development founded in partnership with UCCS, and other local Colorado Universities have engage 285+ persons who actively engage to volunteer time towards making Distributed Ledger a reality in Colorado. This has resulted in Interstate coalition with chapters at UCCS, Denver University, and Arizona State University. Discussion for additional chapters are in progress with Colorado State University, University of Wyoming, Tennessee Tech, University of Notre Dame and University of Arkansas. Expanded relationships with International Electrical and Electronic Engineers (IEEE) will result in this becoming a global footprint.*
    - engagement for a proof-of-concept prototype with an initial state-wide program with a partnership to implement for CDE.
    - Founding community of developers in three chapters, UCCS, Denver University, Arizona State University.
    - Alliances with Colorado Department of Higher Education C-Labs project, International Electrical and Electronic Engineers IEEE, and Denver University Transactive Energy
- **Space ISAC, executing the direction in HB16-1453"** consider establishing relationships with the existing Mitre national cybersecurity federally funded research and development center; the Aerospace Corporation federally funded research and development center"
    - Space ISAC, established a relationship with two national cybersecurity federally funded research and development centers; MITRE and the Aerospace Corporation. MITRE and Aerospace Corporation are founding members of the Space ISAC and contribute to Supply Chain Risk Management Working Group, Information Sharing Working Group, Exercise Task Force, CMMC Task Force, Smallsat Community of Interest, SPD-5 Task Force, and Analyst Working Group.

Other Significant Cybersecurity Accomplishments Resulting from this Funding

- **Initial Operations of the Space ISAC – January 2020**
    - Launched a threat intel platform and information sharing portal.
    - Launched 8 collaborative groups – Information Sharing Working Group, Exercise Task Force, CMMC Task Force, Smallsat Community of Interest, SPD-5 Task Force, Value of Space Summit Task Force, Blockchain Community of Interest and Analyst Working Group.
    - In 2020, Space ISAC conducted the first Value of Space Summit
- **Cybersecurity for State Leaders – Spring 2020**
    - Over 10,000 planned national participants will receive different seminars/presentations providing cybersecurity awareness and hygiene. All of the attendees are state legislators and their staff
- **Cybersecurity workforce development – NCC Student Alliance (NCCSA)**
    - A large part of the Cyber Education program is the NCCSA which helps middle and high schools to either reinforce already existing cyber education programs or build programs where none exist. In FY20, the NCC helped over 35 different schools enhance or create cybersecurity education programs. The program continues to expand across the state and nation
        - NCCSA provided cyber summer camps to middle and high school students. 112 students attended cyber camps hosted by the NCC in FY20.

Impacts of COVID

- **Ethics in Cybersecurity Event** which brough together 135 students, teachers and professionals from 17 states and 5 countries demonstrating expanded virtual participation in events.

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- **UCCS Cyber Club was able to participate in more Cyber Capture the Flag events because of remote/virtual option, broadening their exposure and experience to hands on activities.** Cyber Club was able to participate in 8 Cyber CTFs in 2020-2021
- **Many of the PSI law enforcement training sessions supporting SB18-086 were postponed/rescheduled**
  - Colorado ICAC Undercover Chat
  - Regional ICAC Conference in Colorado Springs
  - FLETC Wi-Fi Tools for Analysis and GEO-Locating (WTAG)
- UCCS/NCC in person conference and seminar travel and presentations eliminated/suspended but virtual participation continued
- NCC National Cybersecurity Symposium planned for June 2020 was cancelled
- **Exponential Impact (XI), non-profit accelerator and incubator, is a partner in the cybersecurity ecosystem. Collaboration between UCCS and XI supports job creation, workforce development, and advances entrepreneurship. XI offers a Seed to Scale pathway for emerging startups that supports their growth from early product development, through rapid growth and Series A investment. In 2021, XI offered the three programs that makeup the Seed to Scale pathway, the Accelerator, Amplify, and Ascend.**
- The Accelerator is a 12-week hybrid (virtual and in-person) program that offers intensive programming, mentorship, and community and investor connections to early-stage companies, who are in the process of refining their minimum viable product. The 2021 Accelerator ran in late summer with four participating startups.
- Amplify is a year-long incubator program that supports startups as they seek to gain traction and grow their company. Startups in the program have access to a whole host of resources including coworking space in the XI Venture Center (in a building shared with UCCS), sessions with XI's Entrepreneurs in Residence, access to subject matter experts, mentors, a network of founders, community leaders, investors, and XI interns to work directly on their projects. The program started in late 2020 with ten participating startups.
- Ascend, a year-long program, is launching in late 2021o support companies looking to rapidly scale and grow their team. Companies in Ascend, the final step in the Seed to Scale initiative, will receive customized mentoring by seasoned entrepreneurs and leadership experts to prepare for high-growth and expansion. The program will include curated leadership events focused on wellness, team building, and connecting with other founders at a similar stage and beyond.
- **The Seed to Scale programs target scalable technology startups, and the partnership with UCCS and the National Cybersecurity Center creates unique opportunities for cybersecurity companies in the XI programs. Additionally, UCCS students frequently work with the startup founders on key business projects along with filling a talent gap for startups, the collaboration provides job training for students.**

COLORADO COMMUNITY COLLEGE SYSTEM

SB 18-086 Appropriation Expenditure Report			
Governing Board Name	Colorado Community College System		
Total SB 18-086 Appropriation		$	182,352
Actual Amount Spent on Scholarships		$	27,500
Total number of scholarships awarded - (See Note 5)			11
Required Allotted Amount Earmarked for Scholarships		$	18,235
At or above allotted amount of scholarship earmark			Yes
Number of faculty/adjucts hired as a result of funding - (See Note 1)			2
Number of student internships created - (See Note 2)			25
Number of degrees/certificates awareded in connection with SB 086 funding - (See Note 3)			59
Number of presentations/seminars given on cybersecurity - (See Note 4)			47
Amount of all other money raised to match state investment			$50,000.00
Total Amount Expended	Colorado Community College System	$	182,352

Please discuss any additional ways in which SB 086 money was spent, which may not be captured in lines 6-9 and fundraising efforts as reported in FY21 and any other information you would like to be included in the report.

Note 1: SB 18-086 funds have been used to pay the salary and benefits for 2 full-time cyber security faculty members. These expenses represent nearly 80% of all appropriation funding.

Note 2: Throughout the pandemic, the Cyber Security Program has been one of the only programs at PPCC to increase in student enrollment. The number of student internships created has increased by 150%. In the previous reporting year, there were 10 internships created - which at that time was the largest cohort of internship students in Cyber Security. In FY21, Cyber Security internships created numbered 25.

Note 3: Since first receiving SB 18-086 funding, the number of degrees and certificates have increased substantially every year - and FY21 is without exception. FY18 had a total of 13 completers, FY19 had 16 total completers, FY20 nearly tripled to 45 total completers. In FY21 we experienced a 31% increase in completers for a total of 59. There were 29 AAS Cybersecurity degrees awarded and 30 Cybersecurity certificates awarded.

Note 4: The number of presentations and seminars given on Cyber Security have increased significantly over the past year. The COVID-19 pandemic presented both positive and negative impacts for the number of presentations and seminars. Students were unable to travel for competitions and conferences or meet for Cyber Club in wats they had previously done in prior years. Even with these hurdles, Cyber Security personnel gave more presentations and seminars than ever before – mostly though the use of remote technologies such as Zoom and Microsoft Teams.

Note 5: PPPC's SB 18-086 funding was decreased from the previous year's $300,000 to $182,235 in FY21. Despite decreased funding, PPCC only awarded 1 less scholarship in FY21 than the previous year. In addition to SB 18-086 scholarship dollars, the PPCC Foundation raised an additional $50,000 for Cyber Security scholarships. PPCC awarded (11) $2,500 scholarships to Cyber Security students, distributed evenly throughout the year.

Additional Notes: Interest and growth in Cyber Security has been significant and shows no signs of diminishing. Continued funding for Cyber Security would create a significant benefit to students and our community.

Conclusion

FY 2020-21 was the third year of additional funding for cybersecurity and distributed ledger technologies. Because of the continuing interruption caused by the COVID-19 pandemic, institutions were limited in the 18-086 activities they were able to carry out. However, institutions remain committed to fully implementing the goals of the legislation.

Outside of offering scholarships to students pursuing degrees and credentials related to cybersecurity, and the hiring of faculty and staff, institutions focused funding on improving their cyber facilities and offering outreach events through cyber centers. With ongoing investment in cybersecurity and ledger technology, institutions will be well equipped to continue to invest in these programs and the students enrolled in them.